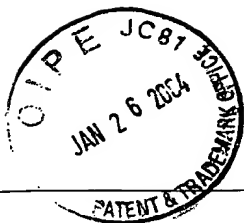




Image #17F

PTO/SB/17 (10-03)  
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FEE TRANSMITTAL for FY 2004 <small>Effective 10/01/2003, Patent fees are subject to annual revision.</small>		Complete if Known		
		Application Number	09/651,998-Conf. #2931	
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27		Filing Date	August 31, 2000	
		First Named Inventor	Er-Xuan Ping	
		Examiner Name	H. J. Tsai	
TOTAL AMOUNT OF PAYMENT (\$)		330.00	Art Unit	2812
		Attorney Docket No.	M4065.0315/P315	
METHOD OF PAYMENT (check all that apply)		FEE CALCULATION (continued)		
<input type="checkbox"/> Check <input checked="" type="checkbox"/> Credit Card <input type="checkbox"/> Money Order <input type="checkbox"/> Other <input type="checkbox"/> None		3. ADDITIONAL FEES		
<input checked="" type="checkbox"/> Deposit Account: Deposit Account Number: 04-1073 Deposit Account Name: Dickstein Shapiro Morin & Oshinsky LLP		Large Entity Small Entity		
The Director is authorized to: (check all that apply)		Fee Code Fee (\$)		
<input type="checkbox"/> Charge fee(s) indicated below <input checked="" type="checkbox"/> Credit any overpayments		Fee Code Fee (\$)		
<input checked="" type="checkbox"/> Charge any additional fee(s) or any underpayment of fee(s)		Fee Description		
<input type="checkbox"/> Charge fee(s) indicated below, except for the filing fee to the above-identified deposit account.		Fee Paid		
FEE CALCULATION				
1. BASIC FILING FEE				
Large Entity Small Entity				
Fee Code Fee (\$)				
1001 770 2001 385		Utility filing fee		
1002 340 2002 170		Design filing fee		
1003 530 2003 265		Plant filing fee		
1004 770 2004 385		Reissue filing fee		
1005 160 2005 80		Provisional filing fee		
SUBTOTAL (1) (\$)		0.00		
2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE				
Total Claims		Extra Claims Fee from below Fee Paid		
Independent Claims				
Multiple Dependent				
Large Entity Small Entity				
Fee Code Fee (\$)				
1202 18 2202 9		Claims in excess of 20		
1201 86 2201 43		Independent claims in excess of 3		
1203 290 2203 145		Multiple dependent claim, if not paid		
1204 86 2204 43		** Reissue independent claims over original patent		
1205 18 2205 9		** Reissue claims in excess of 20 and over original patent		
SUBTOTAL (2) (\$)		0.00		
** or number previously paid, if greater; For Reissues, see above				
SUBMITTED BY		(Complete (if applicable))		
Name (Print/Type) Thomas J. D'Amico		Registration No. (Attorney/Agent) 28,371		
Signature		Telephone (202) 828-2232		
		Date January 26, 2004		



## TRANSMITTAL OF APPEAL BRIEF

Docket No.  
M4065.0315/P315

In re Application of: Er-Xuan Ping et al.

Application No.  
09/651,998-Conf. #2931

Filing Date  
August 31, 2000

Examiner  
H. J. Tsai

Group Art Unit  
2812

Invention: METHOD AND STRUCTURE FOR REDUCING LEAKAGE CURRENT IN CAPACITORS

### TO THE COMMISSIONER OF PATENTS:

Transmitted herewith in triplicate is the Appeal Brief in this application, with respect to the Notice of Appeal filed: November 26, 2003.

The fee for filing this Appeal Brief is 330.00.

☒ Large Entity


☐ Small Entity

☐ A check in the amount of \_\_\_\_\_ is enclosed.

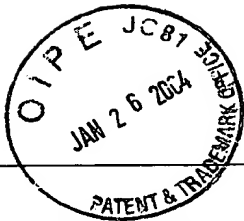
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☒ The Director is hereby authorized to charge any additional fees that may be required or credit any overpayment to Deposit Account No. 04-1073.  
This sheet is submitted in duplicate.

  
\_\_\_\_\_  
Thomas J. D'Amico  
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(202) 828-2232

Dated: January 26, 2004



# TRANSMITTAL OF APPEAL BRIEF

Docket No.  
M4065.0315/P315

In re Application of: Er-Xuan Ping et al.

Application No.  
09/651,998-Conf. #2931

Filing Date  
August 31, 2000

Examiner  
H. J. Tsai

Group Art Unit  
2812

Invention: METHOD AND STRUCTURE FOR REDUCING LEAKAGE CURRENT IN CAPACITORS

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☐ A check in the amount of \_\_\_\_\_ is enclosed.

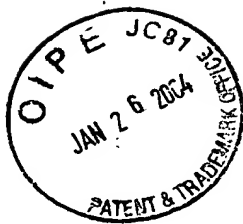
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(202) 828-2232

Dated: January 26, 2004



Docket No.: M4065.0315/P315  
(PATENT)

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Patent Application of:  
Er-Xuan Ping, et al.

Application No.: 09/651,998

Confirmation No.: 2931

Filed: August 31, 2000

Art Unit: 2812

For: METHOD AND STRUCTURE FOR  
REDUCING LEAKAGE CURRENT IN  
CAPACITORS

Examiner: H. Tsai

**APPELLANT'S BRIEF**

MS Appeal Brief - Patents  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

This brief is being submitted pursuant to the Notice of Appeal, filed in this case on November 26, 2003.

The fee required under § 1.17(f) is to be paid in the manner indicated in the accompanying TRANSMITTAL OF APPEAL BRIEF.

This brief is transmitted in triplicate.

**I. REAL PARTY IN INTEREST**

The real party in interest for this appeal is:

MICRON TECHNOLOGY, INC.

01/28/2004 SZEWDIE1 00000047 09651998

01 FC:1402

330.00 OP

1709968 v1; 10NF4011.DOC

## **II. RELATED APPEALS AND INTERFERENCES**

There are no other appeals or interferences which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

## **III. STATUS OF CLAIMS**

There are 59 claims pending in this application.

### **A. Current Status of Claims**

1. Claims canceled: 60-95.
2. Claims pending: 1-59.
3. Claims rejected: 1-59.

### **B. Claims On Appeal**

The claims on appeal are claims 1-59.

## **IV. STATUS OF AMENDMENTS**

The Amendment Under 37 C.F.R. § 1.116 filed on March 27, 2002 was not entered.

The Amendment filed on April 30, 2002 and resubmitted on June 13, 2002 was not entered.

The Amendment filed on May 12, 2003 was entered.

Accordingly, the claims attached herewith as Appendix A incorporate the amendments presented in the Amendment filed on May 12, 2003.

## V. SUMMARY OF INVENTION

The invention provides a method of forming a capacitor, such as that shown in Fig. A below, and capacitor structure in a semiconductor device in which a layer of conductive material is first formed, a layer of a dielectric (which may be a silicon nitride layer as recited in some of the claims) is formed over the conductive layer, the dielectric layer is then contacted with hydrogen, oxygen and nitrous oxide gases to form an oxidation layer over the dielectric layer, and (in the capacitor claims) another layer of conductive material is then formed over the dielectric layer after the oxidation layer is formed.

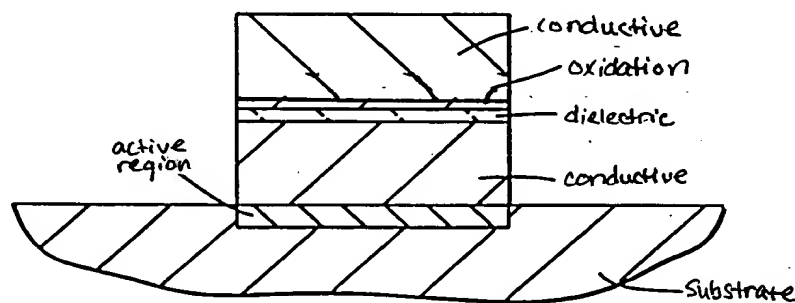


Fig. A

Specifically, the oxidation layer is formed by adding nitrous oxide to a mixture of oxygen and hydrogen gases, and then contacting the dielectric layer with the gaseous mixture. The gas ratio of nitrous oxide to hydrogen and oxygen can be varied by either changing the nitrous oxide gas flow rate while keep the hydrogen and oxygen flow rates constant, or vice versa. The resulting structure exhibits a lowered current leakage with little loss of capacitance when compared with similar capacitor structures in which the dielectric is built with a conventional hydrogen and oxygen treatment which forms an oxidation layer on the dielectric. The invention is more completely defined in the appended claims.

## VI. ISSUES

Whether claims 1-59 are rendered obvious by the combined disclosures of United States Patent Number 6,380,056 to Shue et al. and United States Patent Number 6,207,589 to Ma.

## VII. GROUPING OF CLAIMS

For purposes of this appeal brief only, and without conceding the teachings of any prior art reference, the claims have been grouped as indicated below:

<u>Group</u>	<u>Claims</u>
I.	Claims 1-3, 9-14, 17, 23-24, 40-44, 50 and 57-58 stand or fall together;
II.	Claims 4, 35-37 and 56 stand or fall together;
III.	Claims 6-8, 15-16, 18-22, 25-34, 38-39, 45-46, and 51-55 stand or fall together; and
IV.	Claims 5 and 47-49 stand or fall together.

In Section VIII below, Applicant has included arguments supporting the separate patentability of each claim group as required by M.P.E.P. § 1206.

## VIII. ARGUMENTS

### A. Neither Shue Nor Ma Teaches Or Suggests Forming An Oxidation Layer As Recited In Claims 1 And 40.

1. Neither Shue nor Ma discloses forming an oxidation layer over a dielectric layer (claim 1) or silicon nitride layer (claim 40) as recited in independent claims 1 and 40.

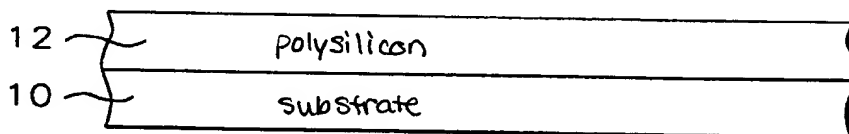
## a. Appellants' Claimed Invention

Claim 1 is directed to a method of forming a capacitor that includes a substrate, a first conductive layer, a dielectric layer, an oxidation layer, and a second conductive layer. Similarly, performance of the method recited in independent claim 40 forms a structure comprising a substrate, a conductive layer, a silicon nitride layer and an oxidation layer. In the structure formed by the method recited in both of these independent claims, an oxidation layer is formed as a separate and distinct layer from the dielectric or silicon nitride layer beneath it.

## b. The Shue Reference

In contrast to the claimed invention, Shue discloses a method of forming a dielectric layer upon a silicon layer for microelectronics fabrication (col. 5, lns. 19-21), wherein the structure formed by Shue's method includes a substrate, a first conductive layer, an oxidized layer, and a second conductive layer. It does not include an oxidation layer formed over a dielectric layer (claim 1) or silicon nitride layer (claim 40) as claimed.

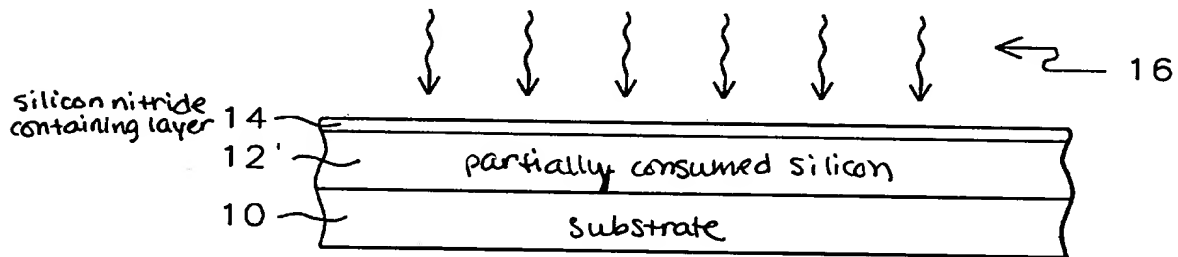
Specifically, Shue discloses first forming a conductive polysilicon layer 12 on a substrate 10 (Shue, Fig. 1).



Shue, Fig. 1 (with text labels added)

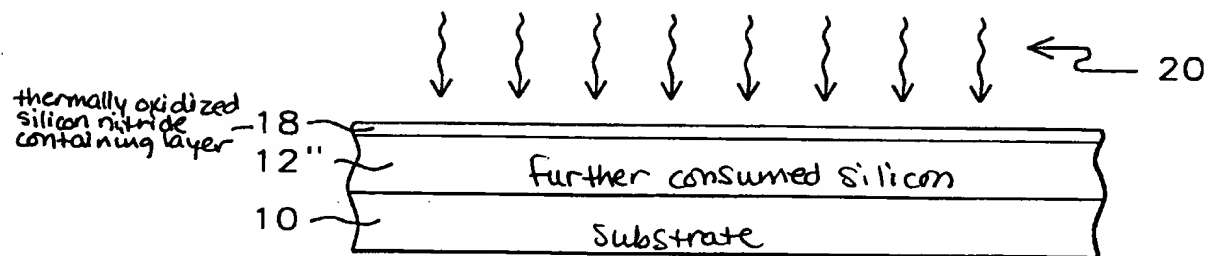


The silicon layer 12 is then annealed in a nitrogen-containing atmosphere to transform the entire layer into a partially consumed silicon layer 12'. While forming the partially consumed silicon layer 12', a silicon nitride containing layer 14 is simultaneously formed on the partially consumed silicon layer 12'. (Shue, Fig. 2 and col. 6, lns. 43-62).



Shue, Fig. 2 (with text labels added)

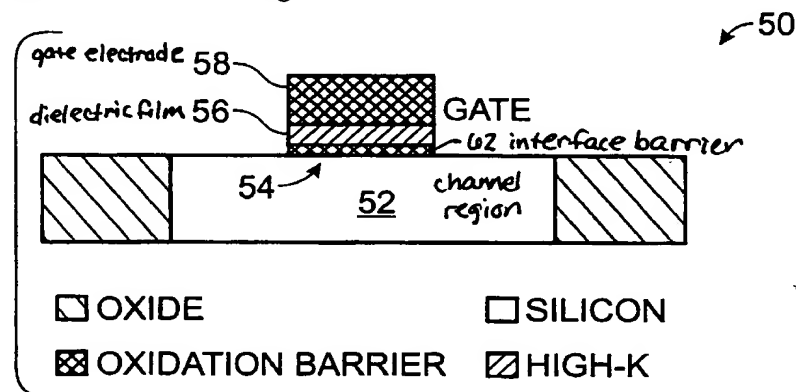
Next, Shue discloses annealing the structure formed thus far in an oxidizing atmosphere to transform the partially consumed silicon layer 12' into a further consumed silicon layer 12'' while simultaneously transforming the silicon nitride layer 14 into a thermally oxidized silicon nitride containing layer 18. (Shue, Figs. 2-3 and col. 7, lns. 25-33). Since the silicon nitride layer 14 is changed into the thermally oxidized silicon nitride containing layer 18, Shue's structure at this point includes an oxidized layer, but no dielectric layer beneath the oxidized layer. Thus, the method disclosed in Shue does not form an oxidation layer over the dielectric (claim 1) or silicon nitride (claim 40) as recited in claims 1 and 40.



Shue, Fig. 3 (with text labels added)

## c. The Ma Reference

Ma discloses a method of forming a high dielectric constant film for use in gate dielectrics and storage capacitors. (Ma, col. 1, lns. 53-57). More particularly, Ma discloses forming an interface barrier 62 consisting of silicon nitride and silicon oxynitride over a silicon channel region 52, forming a dielectric film layer 56 over the interface barrier 62, annealing the film 56, then forming a gate electrode 58 on the annealed film 56, as shown in Fig. 13 in Ma.



Ma, Fig. 13 (with added labels)

The final Office Action relies on Ma for its disclosure of a thickness range for dielectric layer 56. Regardless of the feature(s) disclosed in Ma relied upon in the Office Action, this combination of Shue and Ma is still insufficient to destroy patentability of Appellants' claimed invention, because Ma does not teach the features of the claimed invention lacking in Shue. In particular, Ma fails to teach or suggest forming an

oxidation layer over a dielectric layer (claim 1) or silicon nitride layer (claim 40), as claimed. Thus, the addition of Ma's disclosure to that of Shue still does not render obvious the claimed invention, including, *inter alia*, forming an oxidation layer over a dielectric (or silicon nitride) layer as recited in claims 1 and 40 of this application.

2. Neither Shue nor Ma teaches or suggests forming an oxidation layer by contacting a dielectric layer (claim 1) or silicon nitride layer (claim 40) with hydrogen, oxygen and nitrous oxide gases as recited in independent claims 1 and 40.

a. The Claimed Invention

Claim 1 in the present application recites "contacting said second [dielectric] layer with hydrogen, oxygen and nitrous oxide gases so as to form an oxidation layer over the second layer." Similarly, independent claim 40 recites "contacting said silicon nitride layer with hydrogen, oxygen and nitrous oxide gases so as to form an oxidation layer over said silicon nitride layer."

In the present invention, the claimed combination of gases, i.e. hydrogen, oxygen and nitrous oxide gases, is critical in the formation of the oxidation layer. As discussed throughout Appellants' specification and demonstrated in the experimental data provided in Tables 1 and 2 on pages 13-14 thereof, significant and unexpected reduction in capacitor leakage current is observed when the capacitor dielectric is oxidized with hydrogen, oxygen and nitrous oxide gases as compared with the leakage current obtained when the dielectric layer in the capacitor was oxidized by other gases or gas combinations.

Specifically, the samples of Group I in Tables 1 and 2 were oxidized using only hydrogen and oxygen gases, while the samples in Groups 2-4 were oxidized using a mixture of hydrogen, oxygen, and nitrous oxide. Table 2 shows that the leakage current through the dielectric layers of the samples of Groups 2-4 were greatly reduced from the leakage current through the dielectric layers of the samples of Group 1. For example, for the samples having a dielectric layer thickness of 47 Angstroms, the amount of leakage current obtained upon applying  $-1.6$  V to the capacitors of Groups 1-4 are  $-4.46\text{E-}08$  A/cm<sup>2</sup>,  $-2.05\text{E-}08$  A/cm<sup>2</sup>,  $-1.88\text{E-}08$  A/cm<sup>2</sup>, and  $-1.64\text{E-}08$  A/cm<sup>2</sup>, respectively. This data indicates that the leakage current observed in the samples of Groups 2-4 equate to 46%, 42%, and 37%, respectively, of the leakage current observed in the samples of Group 1.

Although it is not known exactly why the use of the claimed mixture produces such superior results, it is clear that a marked improvement in leakage current suppression does occur when forming the oxidation layer according to the claimed invention.

b. The Shue Reference

Column 7, lines 18-61 in Shue describes the process of converting the silicon nitride containing layer 14 into the thermally oxidized silicon nitride layer 18. While Shue may be considered to disclose oxidizing the silicon nitride containing layer 14 with an admixture of oxygen and nitrous oxide gases as one of a myriad of possible oxidizing gas combinations disclosed in column 7, lines 49-55, Shue never mentions the use of hydrogen gas anywhere in the reference, much less for forming an oxidation layer over a dielectric layer in combination with the oxygen and nitrous oxide gases, as recited in Appellants' claims.

Despite Shue's failure to mention the use of hydrogen gas, the final Office Action appears to imply that claims 11-14 in Shue teaches the use of hydrogen gas in an oxidation process. A careful review of the reference, however, reveals that this is, in fact, not what Shue teaches. Claims 11-14 in Shue are all dependent claims which depend from independent claim 7, and correspond with the discussion on column 6, lines 43-62 and column 7, lines 25-42 and lines 49-61 in Shue's specification. None of claims 12-14 mention hydrogen gas. On the other hand, claim 11 in Shue recites "wherein . . . the reducing material is a hydrogen containing reducing material." There are several reasons why this cited portion of Shue does not even come close to disclosing the use of hydrogen gas in an oxidation process.

First, one of ordinary skill in the art would immediately recognize that a reducing material is used in a reduction process, and that since a reduction process is the opposite of an oxidation process, one would not use a reducing material in an oxidation process, regardless of what the reducing material is.

Second, a "hydrogen containing material" is not per se a teaching of hydrogen gas. Even assuming *arguendo* that this is a teaching of hydrogen gas, Shue

does not teach using the hydrogen gas for oxidizing a dielectric layer or silicon nitride layer.

Third, the context in which the hydrogen gas is discussed in Shue does not support the conclusion proffered in the Office Action. Claim 11 in Shue depends from claim 7, so one must look to claim 7 to determine the significance of the hydrogen containing reducing material recited in claim 11. Claim 7 in Shue recites, essentially, a method which includes annealing a silicon layer to form a “silicon nitride containing layer upon a partially consumed silicon layer,” wherein the annealing process is performed using a “nitrogen containing annealing atmosphere in absence of an oxidizing material or a reducing material.” (Shue, claim 7 at col. 12, lns. 15-20). Claim 11 in Shue therefore recites that the silicon nitride layer and the partially consumed silicon layer are formed in absence of an oxygen containing oxidizing material and a hydrogen containing reducing material. This subject matter recited in claims 7 and 11 in Shue are also discussed in column 6, lines 43-57 thereof, which discloses that “the nitrogen containing annealing atmosphere 16 employs at least nitrogen, but there is also excluded from the nitrogen containing annealing atmosphere 16 an oxidizing material, such as but not limited to an oxygen containing oxidizing material . . . and a reducing material such as but not limited to a hydrogen containing reducing material” (emphasis added).

Additionally, this annealing process described in Shue is performed on a silicon layer, not a dielectric layer. In fact, Shue’s annealing process produces a silicon nitride layer.

As amply demonstrated above, Shue is absolutely devoid of any teaching or suggestion to use hydrogen gas in combination with oxygen and nitrous oxide gases to form an oxidation layer on a dielectric (claim 1) or silicon nitride (claim 40) layer, as claimed in the present application.

## c. The Ma Reference

Ma discloses a method of forming a high dielectric film for use in gate dielectrics and storage capacitors. (Ma, col. 1, lns. 53-57). Like Shue, Ma also does not teach or suggest oxidizing a dielectric layer with the claimed combination of oxygen, hydrogen and nitrous oxide gases to form an oxidation layer thereon. Column 6, lines 28-30 in Ma discloses that the dielectric film is annealed in inert and/or oxidizing gases. O<sub>2</sub> and NO are listed among the oxidizing gases which may be used, but not H<sub>2</sub>. It is noted that Ma discloses "N<sub>2</sub>:H<sub>2</sub> forming gas" as an inert annealing gas, which is well known in the art. There is nothing in this reference, however, which would suggest to one of ordinary skill in the art to use hydrogen gas in combination with oxygen and nitrous oxide gases to form an oxidation layer on the dielectric layer, especially since Ma does not form an oxidation layer on the dielectric layer.

3. Claims 1 And 40 Are Not Rendered Obvious By Shue And Ma.

For all of the reasons discussed above, independent claims 1 and 40 are novel and nonobvious over the combined disclosures of Shue and Ma. Claims 2-3, 9-14, 17, 23-24 and 41-43, 50, 57-58 each depends ultimately from claims 1 and 40, respectively, and as such, are also patentably distinguishable over the cited combination of prior art at least for the same reasons attributable to claims 1 and 40.

B. Neither Shue Nor Ma Teaches Or Suggests Forming The Dielectric Layer To The Specific Thicknesses Or Thickness Ranges Recited In Claims 4, 35-37 And 56.

Claims 4 and 56 each recites that the dielectric layer has a thickness between 45 and 50 Angstroms, while each of claims 35-37 specifically recites that the dielectric layer is 47 Angstroms thick.

The final Office Action concedes that Shue does not disclose forming the dielectric layer to the thicknesses recited in Appellants' claims, but notes that Ma discloses that dielectric layer 56 has a thickness between 2-200 Å. Appellants note, however, that the MPEP § 2131.03 instructs that

If the claims are directed to a narrow range, the reference teaches a broad range, and there is evidence of unexpected results within the claimed narrow range, . . . it may be reasonable to conclude that the narrow range is not disclosed with "sufficient specificity" [in the reference] to constitute an anticipation of the claims.

In this case, Appellants' claimed range of 45-50 Å covers only 2.5% of the 2-200 Å range disclosed in Ma. Furthermore, the claimed dielectric thicknesses yield a significant improvement in leakage current compared to comparable structures formed with thicknesses outside the claimed range.

Tables 1 and 2 on pages 12-13 in Appellants' specification provides results for dielectric layers of 59 Angstroms and 47 Angstroms in each of Groups 1-4. As can be seen from these Tables, the reduction in leakage current in Groups 2-4 over the samples of Group 1 is dramatic for the 47 Angstrom thick dielectric layers (about 60%).



In view of such extraordinary results achieved by the claimed invention and the absence of any suggestion in the prior art to specifically choose to form a dielectric having a thickness corresponding with Appellants' claimed thicknesses, there is no reason why one of ordinary skill in the art would choose the claimed thicknesses over any other in the broad range of 2-200 Å disclosed in Ma.

At the bottom of page 2 to the top of page 3 in the final Office Action, the Examiner contends that a showing of "great improvement and utility" "may still not be patentable if the modification was within the capabilities of one skilled in the art." Such reasoning is not in accordance with established patent law. For example, in Ex Parte Levengood, the Board of Appeals found that "an assertion that one of ordinary skill in the relevant art would have been able to arrive at the appellant's invention because he had the necessary skills to carry out the requisite process steps [] is an inappropriate standard for obviousness." 28 U.S.P.Q.2d 1300, 1301 (1993). Similarly, the Federal Circuit has held that "[w]hile [the prior art] apparatus may be capable of being modified to run the way [the Appellants'] apparatus is claimed, there must be a suggestion or motivation in the reference to do so." In re Mills, 916 F.2d 680, 682, 16 U.S.P.Q.2d 1430, 1432 (1990).

The Examiner cites In re Sola to support his position that despite the superior results achieved with Appellants' claimed invention, the claimed invention "may still not be patentable if the modification was within the capabilities of one skilled in the art." (final Office Action, p. 3, top). In re Sola, 25 U.S.P.Q. 433 (CCPA 1935). A review of the opinion, however, reveals no such holding or reasoning by the court. In Sola, the appellant had presented evidence of commercial success, but the court determined that such evidence could not be accepted because the appellant had previously conceded priority of invention to a third party in an earlier interference proceeding. Thus, In re Sola is inapposite to the current situation.

In view of the above, Appellants respectfully submit to the Board that each of claims 4, 35-37 and 56 are patentably distinguishable over Shue and Ma based on the subject matter recited in the claim, in addition to the patentable features recited in their respective independent claims.

**C. Neither Shue Nor Ma Teaches Or Suggests Contacting The Dielectric Layer With Gas Components At The Flow Rates Or Flow Rate Ranges Recited In Claims 6-8, 15-16, 18-22, 25-34, 38-39, 45-46 And 51-55.**

Claims 6-8, 15-16, 18-22, 25-34, 45-46 and 51-55 each recites flow rates or flow rate ranges of between 1 and 10 standard liters per minute (slm) for at least one of the claimed gas components used to oxidize the claimed dielectric (claim 1) or silicon nitride (claim 40) layer.

Aside from the fact that neither Shue nor Ma discloses the use of oxygen, hydrogen, and nitrous oxide gases together for oxidizing a dielectric or silicon nitride layer as recited in the independent claims, the final Office Action simply dismisses the subject matter recited in these dependent claims listed above. This cursory rejection of the claimed subject matter is supported with assertion that “And, the specific coating thickness, gas flow rate and temperature are taken to be obvious since these variables of art recognized importance which are subject to routine experimentation and optimization . . . ”

Ma lacks any mention of any particular flow rates or flow rate ranges for the gases used in the annealing procedures disclosed in the reference.

On the other hand, Shue provides strong support that Appellants’ claimed flow rates and flow rate ranges are more than conditions attainable by mere “routine

experimentation.” In the method disclosed in Shue, each of the two annealing steps, the relevant gas flow rate ranges from about 1-20 standard cubic centimeters per minute (sccm). Such flow rates are only a fraction of the flow rates used in the claimed invention. Thus, Shue belies the validity of the rationale set forth in the Office Action to support the obviousness rejection of claims 6-8, 15-16, 18-22, 25-34, 45-46 and 51-55.

**D. Neither Shue Nor Ma Teaches Or Suggests Contacting The Dielectric Layer With A Gas Mixture In Which The Component Gases Are Provided At The Relative Amounts Recited In Claims 5 And 47-49.**

Claims 5 and 48 recite a range for the ratio of the relative amounts of the three claimed gases used to oxidize the dielectric or silicon nitride layer. Claims 47 and 49 recite that the oxidizing of the dielectric or silicon nitride layer is performed with a flow rate of nitrous oxide which is greater than the flow rate of oxygen.

As demonstrated above, Shue and Ma, both alone and in combination, fail to suggest the use of nitrous oxide gas, oxygen gas, and hydrogen gas to contact a dielectric or silicon nitride layer to form an oxidation layer on the former. By definition, therefore, claims 5 and 48 are also nonobvious over the cited prior art, since the prior art would have to have all three gases present in the oxidizing process in order to meet these claims.

With respect to claims 47 and 49, oxygen and nitrous oxide gases are both mentioned within a list of gases usable in an annealing phase in each of Shue and Ma. Only in Shue, however, is the use of oxygen and nitrous oxide even suggested to be used together. Specifically, column 7, lines 50-55 in Shue discloses “an admixture of (1) an oxygen or oxygen containing oxidizing material; with (2) a nitrogen or nitrogen and

oxygen containing oxidizing material, such as . . . nitrous oxide.” However, Shue does not disclose any flow rates for the admixture or relative flow rates for the components of the admixture.

Since the subject matter recited in claims 5 and 47-49 are not found in Shue or Ma, such subject matter constitutes further bases for patentability over the prior art, in addition to the patentable features recited in their respective independent claims, as discussed above.

**E. Conclusion.**


In view of the above, Appellants respectfully request the Board to overturn the final rejection of claims 1-59 over Shue in view of Ma.

**IX. CLAIMS INVOLVED IN THE APPEAL**

A copy of the claims involved in the present appeal is attached hereto as Appendix A.

Dated: January 26, 2004

Respectfully submitted,

By 

Thomas J. D'Amico  
Registration No.: 28,371  
DICKSTEIN SHAPIRO MORIN &  
OSHINSKY LLP  
2101 L Street NW  
Washington, DC 20037-1526  
(202) 785-9700  
Attorney for Applicant

APPENDIX A

**Claims Involved in the Appeal of Application Serial No. 09/651,998**

1. A method of forming a capacitor on a substrate in a semiconductor device, comprising:
  - forming a first layer of a conductive material over said substrate;
  - forming a second layer of a dielectric over said first layer;
  - contacting said second layer with hydrogen, oxygen and nitrous oxide gases so as to form an oxidation layer over said second layer; and
  - forming a third layer of conductive material over said second layer.
2. The method of claim 1, wherein said second layer is formed to a thickness not exceeding about 60 Angstroms.
3. The method of claim 1, wherein said second layer is formed to a thickness not exceeding about 50 Angstroms.
4. The method of claim 3, wherein said second layer is formed to a thickness within the range of about 45 to 50 Angstroms.

5. The method of claim 1, wherein the ratio of nitrous oxide to oxygen and hydrogen respectively is in the range of about .05 to about 1.7.

6. The method of claim 5, wherein said contacting is performed with a gas flow rate of at least about 0.5 slm for said nitrous oxide.

7. The method of claim 6, wherein said contacting is performed with a gas flow rate of at least about 2.5 slm for said nitrous oxide.

8. The method of claim 7, wherein said contacting is performed with a gas flow rate of at least about 5 slm for said nitrous oxide.

9. The method of claim 1, wherein said contacting is performed at a temperature within the range of about 600 to 1000°C.

10. The method of claim 9, wherein said contacting is performed at a temperature within the range of about 700 to 900 °C.

11. The method of claim 10, wherein said contacting is performed at a temperature within the range of about 700 to 800 °C.

12. The method of claim 1, wherein said oxidation layer is formed so as to be thinner than said dielectric layer.

13. The method of claim 12, wherein said oxidation layer is formed to a thickness less than about 5 Angstroms.

14. The method of claim 12, wherein said oxidation layer is formed to a thickness less than about 3 Angstroms.

15. The method of claim 1, wherein said contacting is performed is performed with a gas flow rate within the range of about 1 to 15 slm for each of said hydrogen, oxygen and nitrous oxide gases.

16. The method of claim 15, wherein said contacting is performed with a gas flow rate within the range of about 2 to 10 slm for each of said hydrogen, oxygen and nitrous oxide gases.

17. The method of claim 16, wherein said contacting is performed at a temperature within the range of about 600 to 1000°C.

18. The method of claim 17, wherein said contacting is performed at a gas flow rate for said oxygen which is within the range of about 4 to 8 slm.

19. The method of claim 18, wherein said contacting is performed at a gas flow rate for said hydrogen which is within the range of about 4 to 8 slm.

20. The method of claim 19, wherein said contacting is performed at a gas flow rate within the range of about 4 to 8 slm for each of said oxygen and hydrogen.

21. The method of claim 17, wherein said contacting is performed at a gas flow rate within the range of about 2.5 to 10 slm.

22. The method of claim 21, wherein said contacting is performed at a gas flow rate within the range of about 6 to 10 slm.

23. The method of claim 17, wherein said contacting is performed at a temperature within the range of about 700 to 800°C.

24. The method of claim 23, wherein said contacting is performed at a temperature of about 750°C.

25. The method of claim 23, wherein said contacting is performed at a gas flow rate for said hydrogen of about 6 slm.



26. The method of claim 25, wherein said contacting is performed at a gas flow rate for said oxygen of about 6 slm.

27. The method of claim 25, wherein said contacting is performed at a gas flow rate for said nitrous oxide of about 2.5 slm.

28. The method of claim 23, wherein said contacting is performed at a gas flow rate for said nitrous oxide of about 5 slm.

29. The method of claim 23, wherein said contacting is performed at a gas flow rate for said nitrous oxide of about 10 slm.

30. The method of claim 24, wherein said contacting is performed at a gas flow of about 6 slm for said hydrogen, about 6 slm for said oxygen, and about 2.5 slm for said nitrous oxide.

31. The method of claim 24, wherein said contacting is performed at a gas flow rate of about 6 slm for said hydrogen, about 6 slm for said oxygen, and about 5 slm for said nitrous oxide.

32. The method of claim 24, wherein said contacting is performed at a gas flow rate of about 6 slm for said hydrogen, about 6 slm for said oxygen, and about 10 slm for said nitrous oxide.

33. The method of claim 24, wherein said contacting is performed at a gas flow rate of about 6 slm for said hydrogen, about 6 slm for said oxygen, and within the range of about 1 to 15 slm for said nitrous oxide.

34. The method of claim 33, wherein said contacting is performed at a gas flow rate of about 6 slm for said hydrogen, about 6 slm for said oxygen, and within the range of about 2 to 10 slm for said nitrous oxide.

35. The method of claim 23, wherein said second layer is formed to a thickness of about 47 Angstroms.

36. The method of claim 24, wherein said second layer is formed to a thickness of about 47 Angstroms.

37. The method of claim 34, wherein said second layer is formed to a thickness of about 47 Angstroms.

38. The method of claim 35, wherein said oxidation layer is formed to be thinner than said dielectric layer.

39. The method of claim 36, wherein said oxidation layer is formed to a thickness less than about 5 Angstroms.

40. A method of forming a capacitor structure in a semiconductor device, comprising:

depositing a layer of silicon nitride over a conductive layer formed over a substrate;

contacting said silicon nitride layer with hydrogen, oxygen and nitrous oxide gases so as to form an oxidation layer over said silicon nitride layer.

41. The method of claim 40, further comprising forming a second conductive layer over said oxidation layer.

42. The method of claim 41, wherein said second conductive layer is formed of polysilicon.

43. The method of claim 40, wherein said silicon nitride layer is deposited to a thickness not exceeding about 60 Angstroms.

44. The method of claim 40, wherein said silicon nitride layer is deposited to a thickness not exceeding about 50 Angstroms.

45. The method of claim 44, wherein said contacting is performed at a flow rate for said nitrous oxide within the range of about 1 to 10 slm.

46. The method of claim 45, wherein said contacting is performed at a flow rate for said oxygen at a flow rate within the range of about 4 to 8 slm.

47. The method of claim 46, wherein said flow rate for said nitrous oxide is greater than the flow rate for said oxygen.

48. The method of claim 47, wherein the ratio of nitrous oxide to oxygen and hydrogen respectively is in the range of about 0.05 to about 1.7.

49. The method of claim 48, wherein said flow rate for said nitrous oxide is at least greater than the flow rate for said oxygen.

50. The method of claim 40, wherein said contacting is performed at a temperature within the range of about 700 to 800°C.

51. The method of claim 50, wherein said contacting is performed at a gas flow rate for each of said hydrogen and oxygen gases which is within the range of about 4 to 8 slm.

52. The method of claim 51, wherein said contacting is performed at a gas flow rate for said nitrous oxide gas which is at least about 2.5 slm.

53. The method of claim 52, wherein said contacting is performed at a gas flow rate for said nitrous oxide which is at least about 5 slm.

54. The method of claim 53, wherein said contacting is performed at a gas flow rate for said nitrous oxide which is at least about 10 slm.

55. The method of claim 52, wherein said contacting is performed at a gas flow rate for each of said hydrogen and oxygen gases which is about 6 slm.

56. The method of claim 50, wherein said silicon nitride layer is deposited to a thickness of about 45 to 50 Angstroms.

57. The method of claim 56, wherein said oxidation layer is formed to a thickness less than about 5 Angstroms.

58. The method of claim 57, wherein said oxidation layer is formed to a thickness less than about 3 Angstroms.

59. The method of claim 50, wherein said contacting is performed at a gas flow rate of about 6 slm for each of said hydrogen and oxygen gases, and at a gas flow rate within the range of about 2.5 to 10 slm for said nitrous oxide gas.



Docket No.: M4065.0315/P315  
(PATENT)

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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In re Patent Application of:  
Er-Xuan Ping, et al.

Application No.: 09/651,998

Confirmation No.: 2931

Filed: August 31, 2000

Art Unit: 2812

For: METHOD AND STRUCTURE FOR  
REDUCING LEAKAGE CURRENT IN  
CAPACITORS

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Examiner: H. Tsai

**APPELLANT'S BRIEF**

MS Appeal Brief - Patents  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

This brief is being submitted pursuant to the Notice of Appeal, filed in this case on November 26, 2003.

The fee required under § 1.17(f) is to be paid in the manner indicated in the accompanying TRANSMITTAL OF APPEAL BRIEF.

This brief is transmitted in triplicate.

**I. REAL PARTY IN INTEREST**

The real party in interest for this appeal is:

MICRON TECHNOLOGY, INC.

## II. RELATED APPEALS AND INTERFERENCES

There are no other appeals or interferences which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

## III. STATUS OF CLAIMS

There are 59 claims pending in this application.

### A. Current Status of Claims

1. Claims canceled: 60-95.
2. Claims pending: 1-59.
3. Claims rejected: 1-59.

### B. Claims On Appeal

The claims on appeal are claims 1-59.

## IV. STATUS OF AMENDMENTS

The Amendment Under 37 C.F.R. § 1.116 filed on March 27, 2002 was not entered.

The Amendment filed on April 30, 2002 and resubmitted on June 13, 2002 was not entered.

The Amendment filed on May 12, 2003 was entered.

Accordingly, the claims attached herewith as Appendix A incorporate the amendments presented in the Amendment filed on May 12, 2003.



## V. SUMMARY OF INVENTION

The invention provides a method of forming a capacitor, such as that shown in Fig. A below, and capacitor structure in a semiconductor device in which a layer of conductive material is first formed, a layer of a dielectric (which may be a silicon nitride layer as recited in some of the claims) is formed over the conductive layer, the dielectric layer is then contacted with hydrogen, oxygen and nitrous oxide gases to form an oxidation layer over the dielectric layer, and (in the capacitor claims) another layer of conductive material is then formed over the dielectric layer after the oxidation layer is formed.

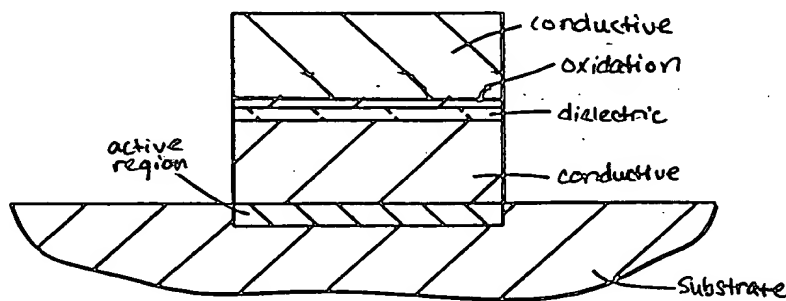


Fig. A

Specifically, the oxidation layer is formed by adding nitrous oxide to a mixture of oxygen and hydrogen gases, and then contacting the dielectric layer with the gaseous mixture. The gas ratio of nitrous oxide to hydrogen and oxygen can be varied by either changing the nitrous oxide gas flow rate while keep the hydrogen and oxygen flow rates constant, or vice versa. The resulting structure exhibits a lowered current leakage with little loss of capacitance when compared with similar capacitor structures in which the dielectric is built with a conventional hydrogen and oxygen treatment which forms an oxidation layer on the dielectric. The invention is more completely defined in the appended claims.

## VI. ISSUES

Whether claims 1-59 are rendered obvious by the combined disclosures of United States Patent Number 6,380,056 to Shue et al. and United States Patent Number 6,207,589 to Ma.

## VII. GROUPING OF CLAIMS

For purposes of this appeal brief only, and without conceding the teachings of any prior art reference, the claims have been grouped as indicated below:

<u>Group</u>	<u>Claims</u>
I.	Claims 1-3, 9-14, 17, 23-24, 40-44, 50 and 57-58 stand or fall together;
II.	Claims 4, 35-37 and 56 stand or fall together;
III.	Claims 6-8, 15-16, 18-22, 25-34, 38-39, 45-46, and 51-55 stand or fall together; and
IV.	Claims 5 and 47-49 stand or fall together.

In Section VIII below, Applicant has included arguments supporting the separate patentability of each claim group as required by M.P.E.P. § 1206.

## VIII. ARGUMENTS

### A. Neither Shue Nor Ma Teaches Or Suggests Forming An Oxidation Layer As Recited In Claims 1 And 40.

1. Neither Shue nor Ma discloses forming an oxidation layer over a dielectric layer (claim 1) or silicon nitride layer (claim 40) as recited in independent claims 1 and 40.

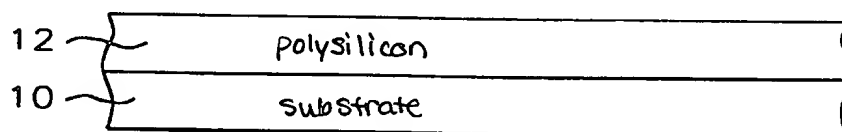
## a. Appellants' Claimed Invention

Claim 1 is directed to a method of forming a capacitor that includes a substrate, a first conductive layer, a dielectric layer, an oxidation layer, and a second conductive layer. Similarly, performance of the method recited in independent claim 40 forms a structure comprising a substrate, a conductive layer, a silicon nitride layer and an oxidation layer. In the structure formed by the method recited in both of these independent claims, an oxidation layer is formed as a separate and distinct layer from the dielectric or silicon nitride layer beneath it.

## b. The Shue Reference

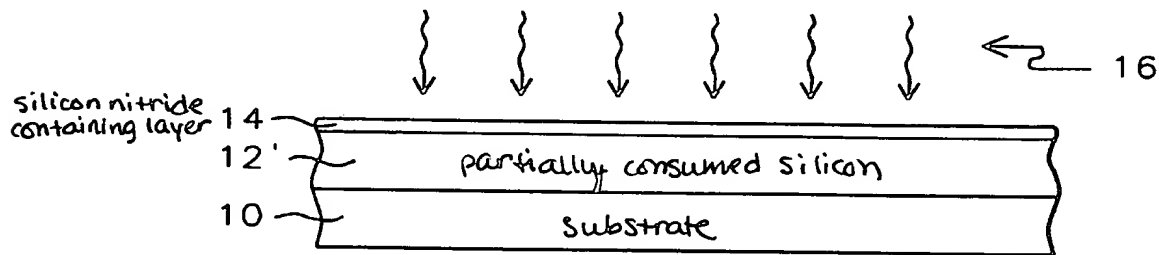
In contrast to the claimed invention, Shue discloses a method of forming a dielectric layer upon a silicon layer for microelectronics fabrication (col. 5, lns. 19-21), wherein the structure formed by Shue's method includes a substrate, a first conductive layer, an oxidized layer, and a second conductive layer. It does not include an oxidation layer formed over a dielectric layer (claim 1) or silicon nitride layer (claim 40) as claimed.

Specifically, Shue discloses first forming a conductive polysilicon layer 12 on a substrate 10 (Shue, Fig. 1).



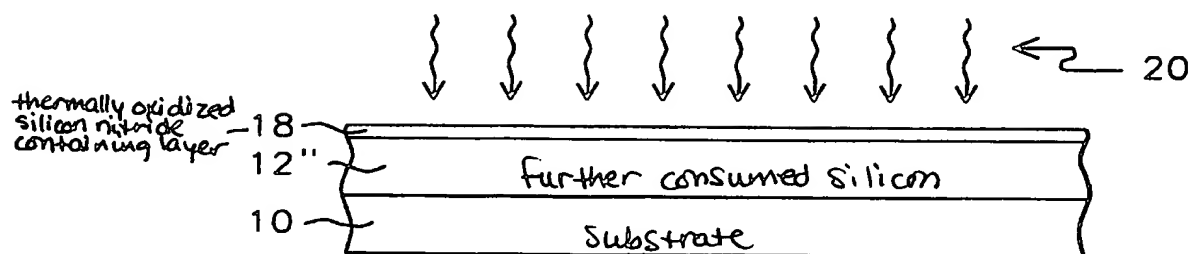
Shue, Fig. 1 (with text labels added)

The silicon layer 12 is then annealed in a nitrogen-containing atmosphere to transform the entire layer into a partially consumed silicon layer 12'. While forming the partially consumed silicon layer 12', a silicon nitride containing layer 14 is simultaneously formed on the partially consumed silicon layer 12'. (Shue, Fig. 2 and col. 6, lns. 43-62).



Shue, Fig. 2 (with text labels added)

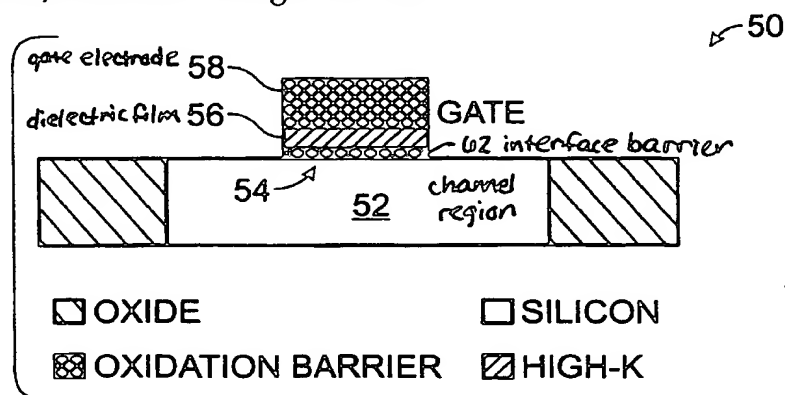
Next, Shue discloses annealing the structure formed thus far in an oxidizing atmosphere to transform the partially consumed silicon layer 12' into a further consumed silicon layer 12'' while simultaneously transforming the silicon nitride layer 14 into a thermally oxidized silicon nitride containing layer 18. (Shue, Figs. 2-3 and col. 7, lns. 25-33). Since the silicon nitride layer 14 is changed into the thermally oxidized silicon nitride containing layer 18, Shue's structure at this point includes an oxidized layer, but no dielectric layer beneath the oxidized layer. Thus, the method disclosed in Shue does not form an oxidation layer over the dielectric (claim 1) or silicon nitride (claim 40) as recited in claims 1 and 40.



Shue, Fig. 3 (with text labels added)

## c. The Ma Reference

Ma discloses a method of forming a high dielectric constant film for use in gate dielectrics and storage capacitors. (Ma, col. 1, lns. 53-57). More particularly, Ma discloses forming an interface barrier 62 consisting of silicon nitride and silicon oxynitride over a silicon channel region 52, forming a dielectric film layer 56 over the interface barrier 62, annealing the film 56, then forming a gate electrode 58 on the annealed film 56, as shown in Fig. 13 in Ma.



Ma, Fig. 13 (with added labels)

The final Office Action relies on Ma for its disclosure of a thickness range for dielectric layer 56. Regardless of the feature(s) disclosed in Ma relied upon in the Office Action, this combination of Shue and Ma is still insufficient to destroy patentability of Appellants' claimed invention, because Ma does not teach the features of the claimed invention lacking in Shue. In particular, Ma fails to teach or suggest forming an

oxidation layer over a dielectric layer (claim 1) or silicon nitride layer (claim 40), as claimed. Thus, the addition of Ma's disclosure to that of Shue still does not render obvious the claimed invention, including, *inter alia*, forming an oxidation layer over a dielectric (or silicon nitride) layer as recited in claims 1 and 40 of this application.

2. Neither Shue nor Ma teaches or suggests forming an oxidation layer by contacting a dielectric layer (claim 1) or silicon nitride layer (claim 40) with hydrogen, oxygen and nitrous oxide gases as recited in independent claims 1 and 40.

a. The Claimed Invention

Claim 1 in the present application recites "contacting said second [dielectric] layer with hydrogen, oxygen and nitrous oxide gases so as to form an oxidation layer over the second layer." Similarly, independent claim 40 recites "contacting said silicon nitride layer with hydrogen, oxygen and nitrous oxide gases so as to form an oxidation layer over said silicon nitride layer."

In the present invention, the claimed combination of gases, i.e. hydrogen, oxygen and nitrous oxide gases, is critical in the formation of the oxidation layer. As discussed throughout Appellants' specification and demonstrated in the experimental data provided in Tables 1 and 2 on pages 13-14 thereof, significant and unexpected reduction in capacitor leakage current is observed when the capacitor dielectric is oxidized with hydrogen, oxygen and nitrous oxide gases as compared with the leakage current obtained when the dielectric layer in the capacitor was oxidized by other gases or gas combinations.

Specifically, the samples of Group I in Tables 1 and 2 were oxidized using only hydrogen and oxygen gases, while the samples in Groups 2-4 were oxidized using a mixture of hydrogen, oxygen, and nitrous oxide. Table 2 shows that the leakage current through the dielectric layers of the samples of Groups 2-4 were greatly reduced from the leakage current through the dielectric layers of the samples of Group 1. For example, for the samples having a dielectric layer thickness of 47 Angstroms, the amount of leakage current obtained upon applying  $-1.6$  V to the capacitors of Groups 1-4 are  $-4.46\text{E-}08$  A/cm<sup>2</sup>,  $-2.05\text{E-}08$  A/cm<sup>2</sup>,  $-1.88\text{E-}08$  A/cm<sup>2</sup>, and  $-1.64\text{E-}08$  A/cm<sup>2</sup>, respectively. This data indicates that the leakage current observed in the samples of Groups 2-4 equate to 46%, 42%, and 37%, respectively, of the leakage current observed in the samples of Group 1.

Although it is not known exactly why the use of the claimed mixture produces such superior results, it is clear that a marked improvement in leakage current suppression does occur when forming the oxidation layer according to the claimed invention.

## b. The Shue Reference

Column 7, lines 18-61 in Shue describes the process of converting the silicon nitride containing layer 14 into the thermally oxidized silicon nitride layer 18. While Shue may be considered to disclose oxidizing the silicon nitride containing layer 14 with an admixture of oxygen and nitrous oxide gases as one of a myriad of possible oxidizing gas combinations disclosed in column 7, lines 49-55, Shue never mentions the use of hydrogen gas anywhere in the reference, much less for forming an oxidation layer over a dielectric layer in combination with the oxygen and nitrous oxide gases, as recited in Appellants' claims.

Despite Shue's failure to mention the use of hydrogen gas, the final Office Action appears to imply that claims 11-14 in Shue teaches the use of hydrogen gas in an oxidation process. A careful review of the reference, however, reveals that this is, in fact, not what Shue teaches. Claims 11-14 in Shue are all dependent claims which depend from independent claim 7, and correspond with the discussion on column 6, lines 43-62 and column 7, lines 25-42 and lines 49-61 in Shue's specification. None of claims 12-14 mention hydrogen gas. On the other hand, claim 11 in Shue recites "wherein . . . the reducing material is a hydrogen containing reducing material." There are several reasons why this cited portion of Shue does not even come close to disclosing the use of hydrogen gas in an oxidation process.

First, one of ordinary skill in the art would immediately recognize that a reducing material is used in a reduction process, and that since a reduction process is the opposite of an oxidation process, one would not use a reducing material in an oxidation process, regardless of what the reducing material is.

Second, a "hydrogen containing material" is not per se a teaching of hydrogen gas. Even assuming *arguendo* that this is a teaching of hydrogen gas, Shue



does not teach using the hydrogen gas for oxidizing a dielectric layer or silicon nitride layer.

Third, the context in which the hydrogen gas is discussed in Shue does not support the conclusion proffered in the Office Action. Claim 11 in Shue depends from claim 7, so one must look to claim 7 to determine the significance of the hydrogen containing reducing material recited in claim 11. Claim 7 in Shue recites, essentially, a method which includes annealing a silicon layer to form a “silicon nitride containing layer upon a partially consumed silicon layer,” wherein the annealing process is performed using a “nitrogen containing annealing atmosphere in absence of an oxidizing material or a reducing material.” (Shue, claim 7 at col. 12, lns. 15-20). Claim 11 in Shue therefore recites that the silicon nitride layer and the partially consumed silicon layer are formed in absence of an oxygen containing oxidizing material and a hydrogen containing reducing material. This subject matter recited in claims 7 and 11 in Shue are also discussed in column 6, lines 43-57 thereof, which discloses that “the nitrogen containing annealing atmosphere 16 employs at least nitrogen, but there is also excluded from the nitrogen containing annealing atmosphere 16 an oxidizing material, such as but not limited to an oxygen containing oxidizing material . . . and a reducing material such as but not limited to a hydrogen containing reducing material” (emphasis added).

Additionally, this annealing process described in Shue is performed on a silicon layer, not a dielectric layer. In fact, Shue’s annealing process produces a silicon nitride layer.

As amply demonstrated above, Shue is absolutely devoid of any teaching or suggestion to use hydrogen gas in combination with oxygen and nitrous oxide gases to form an oxidation layer on a dielectric (claim 1) or silicon nitride (claim 40) layer, as claimed in the present application.

## c. The Ma Reference

Ma discloses a method of forming a high dielectric film for use in gate dielectrics and storage capacitors. (Ma, col. 1, lns. 53-57). Like Shue, Ma also does not teach or suggest oxidizing a dielectric layer with the claimed combination of oxygen, hydrogen and nitrous oxide gases to form an oxidation layer thereon. Column 6, lines 28-30 in Ma discloses that the dielectric film is annealed in inert and/or oxidizing gases. O<sub>2</sub> and NO are listed among the oxidizing gases which may be used, but not H<sub>2</sub>. It is noted that Ma discloses "N<sub>2</sub>:H<sub>2</sub> forming gas" as an inert annealing gas, which is well known in the art. There is nothing in this reference, however, which would suggest to one of ordinary skill in the art to use hydrogen gas in combination with oxygen and nitrous oxide gases to form an oxidation layer on the dielectric layer, especially since Ma does not form an oxidation layer on the dielectric layer.

3. Claims 1 And 40 Are Not Rendered Obvious By Shue And Ma.

For all of the reasons discussed above, independent claims 1 and 40 are novel and nonobvious over the combined disclosures of Shue and Ma. Claims 2-3, 9-14, 17, 23-24 and 41-43, 50, 57-58 each depends ultimately from claims 1 and 40, respectively, and as such, are also patentably distinguishable over the cited combination of prior art at least for the same reasons attributable to claims 1 and 40.

B. Neither Shue Nor Ma Teaches Or Suggests Forming The Dielectric Layer To The Specific Thicknesses Or Thickness Ranges Recited In Claims 4, 35-37 And 56.

Claims 4 and 56 each recites that the dielectric layer has a thickness between 45 and 50 Angstroms, while each of claims 35-37 specifically recites that the dielectric layer is 47 Angstroms thick.

The final Office Action concedes that Shue does not disclose forming the dielectric layer to the thicknesses recited in Appellants' claims, but notes that Ma discloses that dielectric layer 56 has a thickness between 2-200 Å. Appellants note, however, that the MPEP § 2131.03 instructs that

If the claims are directed to a narrow range, the reference teaches a broad range, and there is evidence of unexpected results within the claimed narrow range, . . . it may be reasonable to conclude that the narrow range is not disclosed with "sufficient specificity" [in the reference] to constitute an anticipation of the claims.

In this case, Appellants' claimed range of 45-50 Å covers only 2.5% of the 2-200 Å range disclosed in Ma. Furthermore, the claimed dielectric thicknesses yield a significant improvement in leakage current compared to comparable structures formed with thicknesses outside the claimed range.

Tables 1 and 2 on pages 12-13 in Appellants' specification provides results for dielectric layers of 59 Angstroms and 47 Angstroms in each of Groups 1-4. As can be seen from these Tables, the reduction in leakage current in Groups 2-4 over the samples of Group 1 is dramatic for the 47 Angstrom thick dielectric layers (about 60%).

In view of such extraordinary results achieved by the claimed invention and the absence of any suggestion in the prior art to specifically choose to form a dielectric having a thickness corresponding with Appellants' claimed thicknesses, there is no reason why one of ordinary skill in the art would choose the claimed thicknesses over any other in the broad range of 2-200 Å disclosed in Ma.

At the bottom of page 2 to the top of page 3 in the final Office Action, the Examiner contends that a showing of "great improvement and utility" "may still not be patentable if the modification was within the capabilities of one skilled in the art." Such reasoning is not in accordance with established patent law. For example, in Ex Parte Levengood, the Board of Appeals found that "an assertion that one of ordinary skill in the relevant art would have been able to arrive at the appellant's invention because he had the necessary skills to carry out the requisite process steps [] is an inappropriate standard for obviousness." 28 U.S.P.Q.2d 1300, 1301 (1993). Similarly, the Federal Circuit has held that "[w]hile [the prior art] apparatus may be capable of being modified to run the way [the Appellants'] apparatus is claimed, there must be a suggestion or motivation in the reference to do so." In re Mills, 916 F.2d 680, 682, 16 U.S.P.Q.2d 1430, 1432 (1990).

The Examiner cites In re Sola to support his position that despite the superior results achieved with Appellants' claimed invention, the claimed invention "may still not be patentable if the modification was within the capabilities of one skilled in the art." (final Office Action, p. 3, top). In re Sola, 25 U.S.P.Q. 433 (CCPA 1935). A review of the opinion, however, reveals no such holding or reasoning by the court. In Sola, the appellant had presented evidence of commercial success, but the court determined that such evidence could not be accepted because the appellant had previously conceded priority of invention to a third party in an earlier interference proceeding. Thus, In re Sola is inapposite to the current situation.

In view of the above, Appellants respectfully submit to the Board that each of claims 4, 35-37 and 56 are patentably distinguishable over Shue and Ma based on the subject matter recited in the claim, in addition to the patentable features recited in their respective independent claims.

**C. Neither Shue Nor Ma Teaches Or Suggests Contacting The Dielectric Layer With Gas Components At The Flow Rates Or Flow Rate Ranges Recited In Claims 6-8, 15-16, 18-22, 25-34, 38-39, 45-46 And 51-55.**

Claims 6-8, 15-16, 18-22, 25-34, 45-46 and 51-55 each recites flow rates or flow rate ranges of between 1 and 10 standard liters per minute (slm) for at least one of the claimed gas components used to oxidize the claimed dielectric (claim 1) or silicon nitride (claim 40) layer.

Aside from the fact that neither Shue nor Ma discloses the use of oxygen, hydrogen, and nitrous oxide gases together for oxidizing a dielectric or silicon nitride layer as recited in the independent claims, the final Office Action simply dismisses the subject matter recited in these dependent claims listed above. This cursory rejection of the claimed subject matter is supported with assertion that “And, the specific coating thickness, gas flow rate and temperature are taken to be obvious since these variables of art recognized importance which are subject to routine experimentation and optimization . . . ”

Ma lacks any mention of any particular flow rates or flow rate ranges for the gases used in the annealing procedures disclosed in the reference.

On the other hand, Shue provides strong support that Appellants’ claimed flow rates and flow rate ranges are more than conditions attainable by mere “routine

experimentation.” In the method disclosed in Shue, each of the two annealing steps, the relevant gas flow rate ranges from about 1-20 standard cubic centimeters per minute (scm). Such flow rates are only a fraction of the flow rates used in the claimed invention. Thus, Shue belies the validity of the rationale set forth in the Office Action to support the obviousness rejection of claims 6-8, 15-16, 18-22, 25-34, 45-46 and 51-55.

**D. Neither Shue Nor Ma Teaches Or Suggests Contacting The Dielectric Layer With A Gas Mixture In Which The Component Gases Are Provided At The Relative Amounts Recited In Claims 5 And 47-49.**

Claims 5 and 48 recite a range for the ratio of the relative amounts of the three claimed gases used to oxidize the dielectric or silicon nitride layer. Claims 47 and 49 recite that the oxidizing of the dielectric or silicon nitride layer is performed with a flow rate of nitrous oxide which is greater than the flow rate of oxygen.

As demonstrated above, Shue and Ma, both alone and in combination, fail to suggest the use of nitrous oxide gas, oxygen gas, and hydrogen gas to contact a dielectric or silicon nitride layer to form an oxidation layer on the former. By definition, therefore, claims 5 and 48 are also nonobvious over the cited prior art, since the prior art would have to have all three gases present in the oxidizing process in order to meet these claims.

With respect to claims 47 and 49, oxygen and nitrous oxide gases are both mentioned within a list of gases usable in an annealing phase in each of Shue and Ma. Only in Shue, however, is the use of oxygen and nitrous oxide even suggested to be used together. Specifically, column 7, lines 50-55 in Shue discloses “an admixture of (1) an oxygen or oxygen containing oxidizing material; with (2) a nitrogen or nitrogen and

oxygen containing oxidizing material, such as . . . nitrous oxide.” However, Shue does not disclose any flow rates for the admixture or relative flow rates for the components of the admixture.

Since the subject matter recited in claims 5 and 47-49 are not found in Shue or Ma, such subject matter constitutes further bases for patentability over the prior art, in addition to the patentable features recited in their respective independent claims, as discussed above.

**E. Conclusion.**


In view of the above, Appellants respectfully request the Board to overturn the final rejection of claims 1-59 over Shue in view of Ma.

**IX. CLAIMS INVOLVED IN THE APPEAL**

A copy of the claims involved in the present appeal is attached hereto as Appendix A.

Dated: January 26, 2004

Respectfully submitted,

By 

Thomas J. D'Amico

Registration No.: 28,371

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APPENDIX A

**Claims Involved in the Appeal of Application Serial No. 09/651,998**

1. A method of forming a capacitor on a substrate in a semiconductor device, comprising:
  - forming a first layer of a conductive material over said substrate;
  - forming a second layer of a dielectric over said first layer;
  - contacting said second layer with hydrogen, oxygen and nitrous oxide gases so as to form an oxidation layer over said second layer; and
  - forming a third layer of conductive material over said second layer.
2. The method of claim 1, wherein said second layer is formed to a thickness not exceeding about 60 Angstroms.
3. The method of claim 1, wherein said second layer is formed to a thickness not exceeding about 50 Angstroms.
4. The method of claim 3, wherein said second layer is formed to a thickness within the range of about 45 to 50 Angstroms.



5. The method of claim 1, wherein the ratio of nitrous oxide to oxygen and hydrogen respectively is in the range of about .05 to about 1.7.

6. The method of claim 5, wherein said contacting is performed with a gas flow rate of at least about 0.5 slm for said nitrous oxide.

7. The method of claim 6, wherein said contacting is performed with a gas flow rate of at least about 2.5 slm for said nitrous oxide.

8. The method of claim 7, wherein said contacting is performed with a gas flow rate of at least about 5 slm for said nitrous oxide.

9. The method of claim 1, wherein said contacting is performed at a temperature within the range of about 600 to 1000°C.

10. The method of claim 9, wherein said contacting is performed at a temperature within the range of about 700 to 900 °C.

11. The method of claim 10, wherein said contacting is performed at a temperature within the range of about 700 to 800 °C.

12. The method of claim 1, wherein said oxidation layer is formed so as to be thinner than said dielectric layer.

13. The method of claim 12, wherein said oxidation layer is formed to a thickness less than about 5 Angstroms.

14. The method of claim 12, wherein said oxidation layer is formed to a thickness less than about 3 Angstroms.

15. The method of claim 1, wherein said contacting is performed is performed with a gas flow rate within the range of about 1 to 15 slm for each of said hydrogen, oxygen and nitrous oxide gases.

16. The method of claim 15, wherein said contacting is performed with a gas flow rate within the range of about 2 to 10 slm for each of said hydrogen, oxygen and nitrous oxide gases.

17. The method of claim 16, wherein said contacting is performed at a temperature within the range of about 600 to 1000°C.

18. The method of claim 17, wherein said contacting is performed at a gas flow rate for said oxygen which is within the range of about 4 to 8 slm.

19. The method of claim 18, wherein said contacting is performed at a gas flow rate for said hydrogen which is within the range of about 4 to 8 slm.

20. The method of claim 19, wherein said contacting is performed at a gas flow rate within the range of about 4 to 8 slm for each of said oxygen and hydrogen.

21. The method of claim 17, wherein said contacting is performed at a gas flow rate within the range of about 2.5 to 10 slm.

22. The method of claim 21, wherein said contacting is performed at a gas flow rate within the range of about 6 to 10 slm.

23. The method of claim 17, wherein said contacting is performed at a temperature within the range of about 700 to 800°C.

24. The method of claim 23, wherein said contacting is performed at a temperature of about 750°C.

25. The method of claim 23, wherein said contacting is performed at a gas flow rate for said hydrogen of about 6 slm.

26. The method of claim 25, wherein said contacting is performed at a gas flow rate for said oxygen of about 6 slm.

27. The method of claim 25, wherein said contacting is performed at a gas flow rate for said nitrous oxide of about 2.5 slm.

28. The method of claim 23, wherein said contacting is performed at a gas flow rate for said nitrous oxide of about 5 slm.

29. The method of claim 23, wherein said contacting is performed at a gas flow rate for said nitrous oxide of about 10 slm.

30. The method of claim 24, wherein said contacting is performed at a gas flow of about 6 slm for said hydrogen, about 6 slm for said oxygen, and about 2.5 slm for said nitrous oxide.

31. The method of claim 24, wherein said contacting is performed at a gas flow rate of about 6 slm for said hydrogen, about 6 slm for said oxygen, and about 5 slm for said nitrous oxide.

32. The method of claim 24, wherein said contacting is performed at a gas flow rate of about 6 slm for said hydrogen, about 6 slm for said oxygen, and about 10 slm for said nitrous oxide.

33. The method of claim 24, wherein said contacting is performed at a gas flow rate of about 6 slm for said hydrogen, about 6 slm for said oxygen, and within the range of about 1 to 15 slm for said nitrous oxide.

34. The method of claim 33, wherein said contacting is performed at a gas flow rate of about 6 slm for said hydrogen, about 6 slm for said oxygen, and within the range of about 2 to 10 slm for said nitrous oxide.

35. The method of claim 23, wherein said second layer is formed to a thickness of about 47 Angstroms.

36. The method of claim 24, wherein said second layer is formed to a thickness of about 47 Angstroms.

37. The method of claim 34, wherein said second layer is formed to a thickness of about 47 Angstroms.

38. The method of claim 35, wherein said oxidation layer is formed to be thinner than said dielectric layer.

39. The method of claim 36, wherein said oxidation layer is formed to a thickness less than about 5 Angstroms.

40. A method of forming a capacitor structure in a semiconductor device, comprising:

depositing a layer of silicon nitride over a conductive layer formed over a substrate;

contacting said silicon nitride layer with hydrogen, oxygen and nitrous oxide gases so as to form an oxidation layer over said silicon nitride layer.

41. The method of claim 40, further comprising forming a second conductive layer over said oxidation layer.

42. The method of claim 41, wherein said second conductive layer is formed of polysilicon.

43. The method of claim 40, wherein said silicon nitride layer is deposited to a thickness not exceeding about 60 Angstroms.

44. The method of claim 40, wherein said silicon nitride layer is deposited to a thickness not exceeding about 50 Angstroms.

45. The method of claim 44, wherein said contacting is performed at a flow rate for said nitrous oxide within the range of about 1 to 10 slm.

46. The method of claim 45, wherein said contacting is performed at a flow rate for said oxygen at a flow rate within the range of about 4 to 8 slm.

47. The method of claim 46, wherein said flow rate for said nitrous oxide is greater than the flow rate for said oxygen.

48. The method of claim 47, wherein the ratio of nitrous oxide to oxygen and hydrogen respectively is in the range of about 0.05 to about 1.7.

49. The method of claim 48, wherein said flow rate for said nitrous oxide is at least greater than the flow rate for said oxygen.

50. The method of claim 40, wherein said contacting is performed at a temperature within the range of about 700 to 800°C.

51. The method of claim 50, wherein said contacting is performed at a gas flow rate for each of said hydrogen and oxygen gases which is within the range of about 4 to 8 slm.

52. The method of claim 51, wherein said contacting is performed at a gas flow rate for said nitrous oxide gas which is at least about 2.5 slm.

53. The method of claim 52, wherein said contacting is performed at a gas flow rate for said nitrous oxide which is at least about 5 slm.

54. The method of claim 53, wherein said contacting is performed at a gas flow rate for said nitrous oxide which is at least about 10 slm.

55. The method of claim 52, wherein said contacting is performed at a gas flow rate for each of said hydrogen and oxygen gases which is about 6 slm.

56. The method of claim 50, wherein said silicon nitride layer is deposited to a thickness of about 45 to 50 Angstroms.



57. The method of claim 56, wherein said oxidation layer is formed to a thickness less than about 5 Angstroms.

58. The method of claim 57, wherein said oxidation layer is formed to a thickness less than about 3 Angstroms.

59. The method of claim 50, wherein said contacting is performed at a gas flow rate of about 6 slm for each of said hydrogen and oxygen gases, and at a gas flow rate within the range of about 2.5 to 10 slm for said nitrous oxide gas.